The conservation of ecological diversity of Mediterranean ecosystems through ecological management

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Introduction

The object of nature conservation is not only the preservation of certain plant and animal species, threatened by extinction, but also of the ecological diversity and stability of whole ecosystems endangered by urban and industrial expansion.

The purpose of this paper is to outline some of the problems encountered by the conservation of such ecosystems in the mountainous Mediterranean region of Israel and to re-evaluate some of the conventional assumptions on Mediterranean hill-land use.

Mediterranean mountain and hill land ecosystems and their anthropogenic nature

In Israel, as well as in other countries with a similar summer-dry subtropical climate of the Koeppen (1923) Cs, or the UNESCO (1963) xero- and thermo-Mediterranean type, and with a long history of intensive and destructive land use, the only true 'wildlands' are located in the mountainous regions. These are larger areas covered by natural vegetation and on sites too steep or rocky, with soils too shallow for arable farming.

Such untillable wildlands constitute about 40 per cent of the total area in northern and central Israel (Seligman *et al.* 1959), 57 per cent in Greece (Margaropoulos 1952), 64 per cent in Lebanon (Tisdale 1967) and probably not much less in other countries bordering the southern and eastern portions of the Mediterranean. They have been exposed to human activities for a very long period and at least since the Mousterian and Upper Paleolithic period, the primeval, Pleistocene forests of these uplands were influenced by fire, hunting, food gathering and human settlement. After the Late Mesolithic

and Early Neolithic agricultural revolution, and particularly during historic times, grazing and browsing of domestic livestock, woodcutting, brush clearing and cultivation caused the extinction of big mammals—herbivores and most of their predators, the loss of the taller trees, the erosion of the upper soil profile and the impairment of watersheds, and, finally, in overall desiccation (Whyte 1961). Thus these climax forests have been turned into human-degraded and converted upland ecosystems of sclerophyll woodland, scrubland, savannas and derived grasslands. Probably only on the most remote and inaccessible niches such as steep, rocky cliffs and crevices, some artefacts of the original vegetation may have survived. We can assume that some time during the period of abandonment and neglect, following the Muslim Conquest in the Middle Ages, a new dynamic equilibrium has been established between these habitats (now more exposed and drier) and those components of the wildlife which have been best adapted to these semi-natural conditions. Others, succumbing to the pressure of fire, man, his livestock and cultivation, have been replaced by invaders, with broader ecological tolerances, from adjacent more arid regions.

In this way, the landscape has been moulded into a strikingly diverse vegetation pattern. This varies from more or less open multilayered strata of higher and lower phanerophytes, chamaephytes, hemicryptophytes, geophytes and therophytes, to closed, floristically and faunistically much poorer and almost impenetrable one- or two-layered brush thickets. Eig (1927) subdivided this vegetation into 'Maquis', dominated by trees, 'Garigue', dominated by shrubs up to one metre in height and 'Batha', when dominated by a mixture of dwarf shrubs, hemicryptophytes and therophytes. Whereas most of the sclerophyllous hardwood species are considered of low economic value for forest production, the herbaceous layer contains many valuable pasture grasses and legumes and a profusion of beautiful, flowering winter annuals and flowering geophytes from the Liliaceae, Iridaceae, and Orchidaceae families.

However, since the foundation of the State of Israel, this equilibrium has been disturbed again in those parts of the mountainous regions where year-round grazing and browsing of Arabic cattle and goats and the traditional patch-cultivation has been replaced by intensive, seasonal grazing of large beef-cattle and milk-sheep herds and by modern, mechanized methods of land preparation and hill cultivation. In recent years, the greatest impact on this landscape has been the large-scale afforestation by densely planted Allepo pines and the rapid process of urbanization, industrialization, water and road development which has reached the most remote Arabic villages in this region. Anagnostopoulos (1967) describes a similar situation in Greece.

In this way, great parts of these upland 'wildlands' have been lost altogether and most of the remaining are changing rapidly. Smaller but most

significant portions, from the ecological and scenic point of view, have been declared as Nature Reserves or National Parks. Here, and in the remaining open areas, which are now the last resources for outdoor recreation and tourism in the Mediterranean, mountainous region of Israel and in other Mediterranean countries, the need for sound ecological management is very acute.

The need for a holistic and dynamic approach to ecological classification and management

Most of our present information on the vegetation of these wildlands is derived from extensive ecological and phytosociological studies (Zohary 1962). These have been inspired by the Zürich-Montpellier School in which subjective, pseudo-taxonomical and hierarchical classification of 'vegetation classes' and 'climax communities' are used. In addition to the basic objections to this method by Egler (1954), Poore (1955) and others, its drawback for our purpose lies in the emphasis on such preconceived concepts as 'climax communities'. This approach ignores the fact that in the Mediterranean region, fire, man, his axe and livestock have become inseparable and integral parts of these semi-natural ecosystems. Therefore, their exclusion cannot be regarded as creating a 'natural' situation, which will lead to the re-establishment of an hypothetical 'climax'. On the contrary it may lead to a less 'natural' situation—at least from the point of view of biological diversity and stability.

In Europe, where the human impact on natural vegetation has been shorter but not less intensive, this Clementsian climax concept is being replaced by a more realistic term, 'potential natural vegetation' (Tüxen 1956). Also, pseudo-taxonomic, phytosociological classifications have been replaced by broader and more objective ecological classifications (Ellenberg 1963).

The semi-natural status of woodlands and grasslands has also been recognized in conservation management and research in Great Britain (Ovington 1964). This dynamic and holistic approach should also be adopted in Israel and other Mediterranean countries. The object should be the conservation of the structural and functional continuity of these modified ecosystems and thereby their biological diversity.

For this purpose, a more comprehensive ecological classification will be necessary, subdividing the ecosystems into smaller landscape units and ecotopes on a basis of habitat, flora, fauna, biotic history, present and potential utilization. For the vegetation inventory, objective sampling methods should be developed to deal with the three main, closely integrated patterns of spatial variability in vegetation composition, density and structure. These include gradual 'continuum' changes along environmental gradients—similar

to those defined by Whittaker (1960) for California, and more abrupt changes in parent material, soil, topography and rockiness. Superimposed on this environmentally conditioned variability are spatial changes induced by the differential biotic history.

The effect of human interference versus protection on Mediterranean upland ecosystems

Our present knowledge of the long-term effects of different modes and intensities of grazing, burning, cutting, etc., which could serve as a basis for management practices, is only fragmentary and has probably been influenced by many subjective impressions and misconceptions.

Our earlier work in connection with range management and improvement in the Galilee (Naveh 1955, 1960, 1962*a*, 1970) and our present ecological studies on Mount Carmel and the Samarian Hills indicate that the dynamic equilibrium between the taller, more aggressive woody species and hemicryptophytes and the lower herbaceous plants—including flowering geophytes and annual pasture plants—is very vulnerable and is regulated chiefly by the amount and kind of anthropogenic pressure exerted.

The adverse effect on woody Mediterranean vegetation of heavy, uncontrolled grazing, especially if combined with frequent burning and indiscriminate cutting, is well known. Depending on local site conditions and climate and on initial floristic composition, this is leading to domination by a few species of stunted trees and shrubs which are either thorny or aromatic and unpalatable. Germination is also encouraged by fire, for example *Rhamnus palaestina*, *Calycotome villosa*, *Poterium spinosum*, *Cistus and Salvia* spp., or else they are too resistant to grazing and fire to be killed out completely, as with *Pistacia lentiscus* (Naveh 1960).

The effect of 'overgrazing' on the herbaceous plants is much more complex and depends on the species of herbivore and on the timing and intensity of grazing pressure (Seligman *et al.* 1959). Typical pasture swards of mediterranean open woodlands, oak savannas and derived grasslands contain a great number of hardy and early-maturing annual, winter and spring growing grasses, legumes and forbs. These fluctuate in relation to climate and management and most are eaten at one time or another by Arabic cattle, goats, sheep or donkeys during year-round grazing. Because of frequent defoliation the productivity of these plants is low. After the first rains, during early winter germination and growth, when food is very scarce for herbivores and the soil is still bare, the greatest damage is inflicted on these pastures.

On the other hand, grazing by large beef cattle and milk-sheep herds in the vicinity of Jewish settlements is much more selective and confined chiefly to the winter and spring growth seasons. Therefore, if uncontrolled, it might

be even more detrimental to the soil and may lead to the domination of a few less palatable and aggressive forbs and thistles and—because there is no browsing by goats—to reinvasion by woody plants.

Systematic studies in the Lower Galilee in typical Vallonea Oak savanna pastures have shown that by adjusting the timing and intensity of grazing in relation to the vegetative and reproductive requirements of *Avena sterilis* (the most valuable annual grass) this dynamic equilibrium can be shifted in favour of the more productive and nutritious grasses, clovers and medics. By such a rotational-deferred grazing system, the initial output of these degraded pastures has been doubled and, with additional improvements, such as NP fertilizers, selective spot-spray of weeds and perennial thistles and oak thinning, even trebled. (Naveh 1962*a*, 1970.) Similar integrated pasture ecosystem management in fenced paddocks has been adopted now by progressive farmers and collective settlements in Israel.

Although not yet measured quantitatively, it appears as if moderate and especially rotational-deferred grazing also has beneficial effects on many flowering annuals and geophytes, provided that no blanket spraying with 2, 4– is applied. In this respect, sheep seem to be less desirable than cattle because of their greater preference for broadleaved plants of the Compositae and other families. On several occasions we observed that sheep, developed a special liking for *Cyclamen persicum*, selecting their flowers systematically.

That complete and prolonged protection is by no means preferable to moderate grazing for the conservation of ecological diversity in these Mediterranean pastures is clearly demonstrated in Table 1. The higher cover percentages of tall hemicryptophytic thistles and shade tolerant perennial grasses and a reduction in the number of species is very typical in this respect. Sampling was not intensive enough to detect statistically meaningful differences in plants with very low coverage, such as *Ranunculus asiaticus* and *Cyclamen persicum*. But their greater frequencies in the grazed plot indicate that complete protection is not necessary for their conservation and might even be detrimental.

The important role of human interference in the encouragement of light-demanding geophytes and especially Orchidaceae in Mediterranean forests and shrublands was demonstrated on Site 1—a heavily browsed, previously burned and otherwise disturbed site (Table 2). Here, many other herbaceous perennials, as well as annual plants not listed in this Table, have been recorded. Site 2 is representative of the natural Allepo pine forests and open Maquis in the Carmel Park, which are being gradually invaded by taller woody plants, resulting in the reduction of frequency and vitality of geophytes. Site 3 is a typical example of the floristic impoverishment and the simplification of ecological diversity of natural upland ecosystems, induced by pine afforestation. Here, planted pine trees have replaced most of the Maquis trees,

shrubs and their climbers, and from the profusion of geophytes only two, more shade tolerant, Orchidaceae, and five other geophytes have survived, chiefly on the edges of the forest. All of these Orchidaceae and most of the other geophytes, recorded by us in the Carmel National Park, prefer well-lighted niches and are mainly found in grassy or rocky openings, near pathways and edges of trees or shrubs or where the shrub canopy has been lowered and opened by browsing, cutting or burning. Apparently they can take immediate advantage of newly exposed sites and concentrate therefore in recently cleared picnic grounds on the forest edges and, as in Site 1, on previously burned areas.

Table 1. Comparison of botanical composition of two adjacent vallonea oak savanna pastures after 8 years of protection versus grazing. Neve Yaar (Lower Galilee) Spring 1962. Coverage percentages determined by 400 point quadrats along 4 transects.

	Protected pasture	Grazed pasture
Perennial grasses*	15·1	3·2
Annual grasses	32·3	40·6
Legumes	7·3	10·9
Forbs	28·7	37·7
Flowering geophytes:		
Ranunculus asiaticus L.	0	1·1
Cyclamen persicum Mill.	0·5	1·9
Perennial thistles:		
Carlina involucrata Pair	5·9	0·7
Echinops blancheanus Boiss.	1·2	0·9
Bare soil	1·0	3·0
	100·0	100·0

* In protected pasture, mainly *Dactylis glomerata*; in grazed plot mainly *Hordeum bulbosum* L.

Consequently the occurrence of a typical heliophytic orchid, *Ophris fuciflora*, is closely related to light intensity, as regulated by shrub density and height. This is shown in Fig. 1—a typical chart quadrat and profile transect from this site. Here, it appears mainly amongst the low *Pistacia lentiscus* canopy regenerating after fire, where light intensity is almost as high as in the open and reaches 1·35 g cal/cm min. Even where it grows amongst the taller and more dense *Genista sphacelata* shrubs, the light intensity is still above the threshold of 0·11 g cal/cm min found by us for Orchidaceae. This threshold is the same also for *Cephalanthera longifolia* which can be regarded as a facultative sciophyte. Therefore—as shown in Fig. 2—it appears in open

Table 2. Relative abundance of trees, shrubs, climbers and geophytes in three biotopes with different biotic history on Mount Carmel (Spring 1969)

Upper Tree Layer	(1)	(2)	(3)
Pinus pinea L.	+		
Pinus halepensis Mill.	1	4	5
Quercus calliprinos Webb.	3		
Ceratonia siliqua L.	+		
Genista sphacelata Dec.		1	
Crataegus officinalis L.	+		
Lower Tree Layer			
Arbutus andrachne L.	+	3	1
Rhamnus alaternus L.		+	
Styrax officinalis L.	+	+	
Laurus nobilis L.		1	
Quercus calliprinos Webb.	+	4	2
Pistacia palaestina Boiss.	+	1	
Phillyrea media L.		2	1
Crataegus azarolus L.	+	2	1
Cercis siliquastrum L.		+	

Shrub Layer	(1)	(2)	(3)
Pistacia lentiscus L.	2	1	3
Calycotome villosa (Doir) Lk.	1	2	
Genista sphacelata Dec.	2	2	2
Rhamnus palaestina Boiss.	+	+	1
Climbers			
Rubia tenuifolia D'Urv		1	+
Smilax aspera L.		1	+
Tamus communis L.		1	+
Asparagus aphyllus L.		1	+
Clematis cirrhosa L.		1	
Lonicera etrusca Santi.		+	
Prasium majus L.		1	+
Convolvulus scammonia L.		1	+
Bryonia syriaca Boiss.			+

Geophytes Layer (Orchidaceae)	(1)	(2)	(3)
Ophrys sintenisii Fleisch et Bornm	3	+	
Ophrys dinsmorei Schltr	1	2	
Ophrys fuciflora Hal	3		
Ophrys bornmuelleri M. Scheuze	3	1	
Ophrys lutea Cav.	1	+	
Ophrys fusca LK.	1	+	
Ophrys iricolor Desf.	1		
Serapias vomeracea (Burm) Brig.	2		
Anacapiptis pyramidalis (L) Rich			1
Orchis papilionacens L.	2	+	
Orchis anatolicus Boiss		+	
Orchis galilaeus Schltr.	3	+	
Orchis tridentatus Scop.	2	2	
Cephalanthera longifolia (Huds) Fritsch	3	2	
Limodorum abortivum (L.) Sw.			1

Other Geophytes	(1)	(2)	(3)
Asphodelus microcarpus Viv.	2	1	2
Asphodelus tenuifolius Cav.	+		
Allium ampeloprasum L.		+	
Allium neapolitanum Cyr.	+		
Allium hirsutum Zucc.	2	1	1
Ornithogalum narbonense L.	1	1	
Iris sisyrinchium L.	1		
Iris palaestina (Bad) Boiss.	1		
Arisarum vulgare Targ.		1	
Arum dioscoridis S. et S.	+	1	
Anemone coronaria L.	1	1	1
Ranunculus asiaticus L.	2	1	
Cyclamen persicum Mill.	1	1	2
Thrincia tuberosa (L) Lam. et DC	2	1	2
Bellis silvestris Cyr.	2	1	

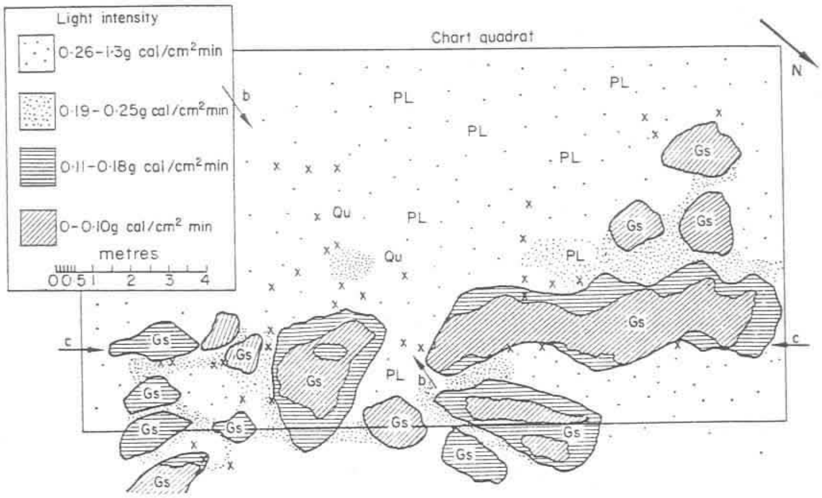
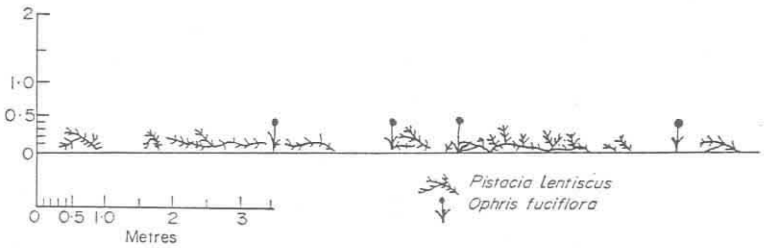
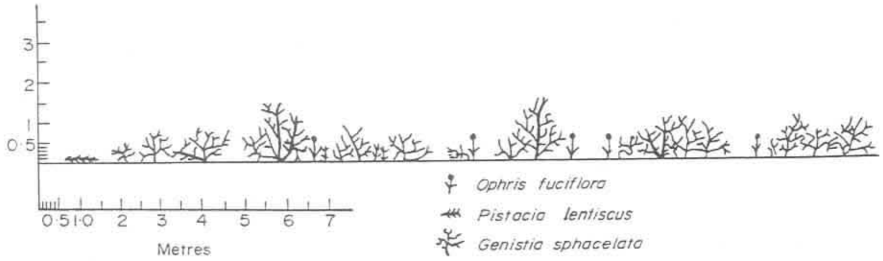


Figure 1. (*a*) Distribution of *Ophris fuciflora* (×) as related to light intensity in a disturbed *Genista sphacelata* (Gs) and *Pistacia lentiscus* (PL) stand at the Carmel National Park. The measurements were carried out in the spring of 1970 with solarimeter CM2 at 1030 h. The arrows point to the sites where the corresponding profile transects were made.



(*b*) Profile transect as indicated in Fig. 1(*a*).



(*c*) Profile transect as indicated in Fig. 1(*a*).

niches or amongst the low *Pistacia lentiscus* canopy, but only where the horizontal branches of *Pinus halepensis* are not more than 4·0 m above the ground.

The attempt to convert the few remaining, natural and open Allepo pine stands on Mount Carmel into dense, artificial pine plantations and thereby

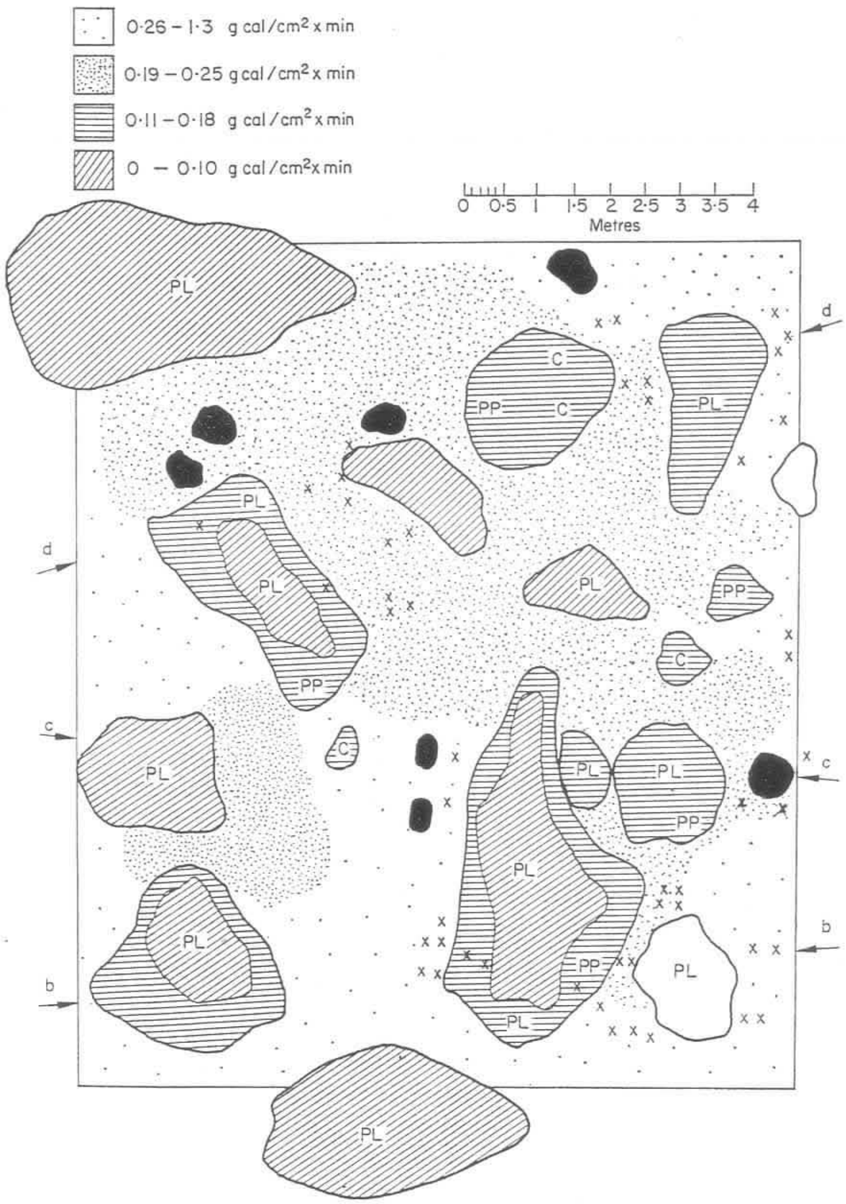
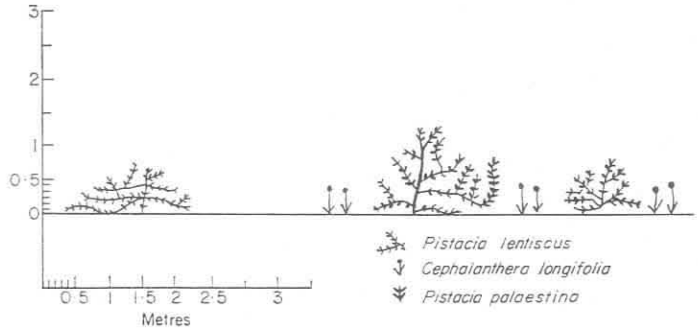
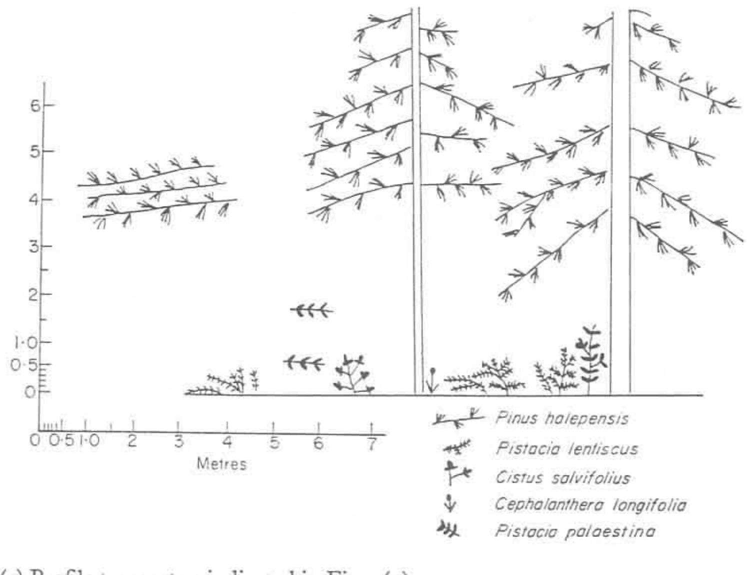


Figure 2. (*a*) Distribution of *Cephalanthera longifolia* (×) as related to light intensity in a *Pinus halepensis* (black area) and *Pistacia lentiscus* (PL) stand at the Carmel National Park. The measurements were carried out in the spring of 1970 with solarimeter CM2 at 0930 h. The arrows point to the sites where the corresponding profile transects were made. Other plants present are the *Pistacia palaestina* (PP) and *Cistus salvifolius* (C).

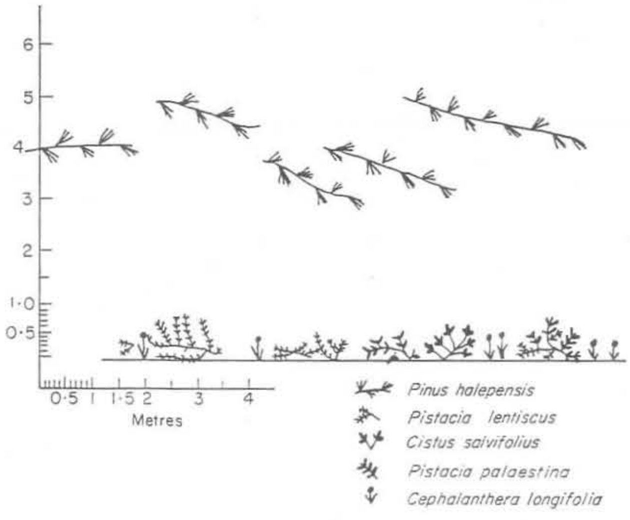


(*b*) Profile transect as indicated in Fig. 2(*a*).



(*c*) Profile transect as indicated in Fig. 2(*a*).

to sacrifice much of their special scenic, recreational and wildlife values is most regrettable. This is especially so in view of the low timber and forest production potential of such rocky hill sites. The situation is even worse in regular, commercial pine afforestations, where up to 2,500 trees per ha are planted. Here, the lack of light and the accumulation of slowly decomposing needle leaf-litter, apparently containing germination-inhibition kolines (Yardeni & Evenari 1952), are even less inducive to the development of a herbaceous understorey. This correlation between the density of the pine canopy and needle-litter mulch and absence of a herbaceous vegetation was revealed also in a recent extensive forest survey in Israel (Duer, pers. comm.).



(*d*) Profile transect as indicated in Fig. 2(*a*).

In Table 3 an interesting example is presented of the 'natural potential vegetation' which might be expected after 50 years of complete protection of Maquis *Quercus calliprinos—Phyllirea media* in a Nature Forest Reservation, established by the British Mandatory Forest Service after World War I in the Samarian mountains. These vegetation records were collected only with the greatest difficulty because of the great density and inaccessibility of the tree and shrub canopy. From 20 woody species, listed altogether on the north (most mesic) slope, only 5 gained any importance and very few herbaceous plants found their last refuge near rock edges.

Recent studies on Mount Carmel (Rosenzweig 1969, Shachori *et al.* 1968) have shown that sclerophyll and evergreen, deep-rooted trees such as *Quercus calliprinos*, and to a lesser degree also *Pinus halepensis*, are, during the summer, depleting the water surplus stored in the karstic-limestone rocks down to 8–10 m. Their water consumption is therefore 100–350 cub. m. higher than that of the winter and spring growing herbaceous plants. Consequently, this water is lost for spring flow and ground water storage in the catchment areas of these brush-covered watersheds, and thereby for irrigation, wildlife and recreation.

Unfortunately, we lack reliable information on the trophic structure, energy flow and nutrient cycling in these ecosystems. But we can safely assume that in such closed, uniform and monotonous Maquis thickets there are fewer favourable niches and edge habitats available for insects, reptiles, birds and mammals, than in their unprotected, open and multi-layered counterparts. The loss of floristic and structural diversity will be reflected in

Table 3. Coverage and abundance of woody plants in closed maquis after 50 years of protection. 'Um Rechan Forest Preservation'—Samarian Mountains. Altitude 400–70 m; North slope 40–45 per cent, very rocky, dark Terra rosa soil.

Name of Species	% cover* in quadrate	Number† plants in transects
Trees (2–5 m ht)		
Quercus calliprinos Webb.	40	157
Phillyrea media L.	27	160
Pistacia palaestina Boiss.	8	86
Rhamnus alaternus L.	+	2
Quercus ithaburensis Bois.		24
Quercus infectoria Oliv.		2
Arbutus andrachne L.		3
Styrax officinalis L.	+	2
Crataegus azarolus L.	+	6
Cercis siliquastrum L.		
Shrubs (1–2 m ht)		
Pistacia lentiscus L.	75	48
Rhamnus palaestina Boiss.	3	29
Calycotome villosa (Doir.) Lk.	4	61
Dwarf shrubs—< 1 m ht		
Cistus salvifolius L.	13	93
Poterium spinosum L.		1
Climbers		
Rubia tenuifolia D'Urv	+	
Smilax aspera L.	+	
Asparagus aphyllus L.	+	
Clematis cirrhosa L.	+	

* Cover estimated in 13 quadrats of 10 × 10 m along 9 transects of 150–200 m.
† Number of plants in 7 transects, 1,340 m long (2 transects too steep and rocky for exact counting).

a lower efficiency of energy interception and transfer and a reduction in channels for nutrient and water circulation and storage capacity. In thermodynamic terms this means an increase of entropy at the cost of all-over productivity and stability. It might be manifested by the great vulnerability to fire of these dense Maquis stands, accumulating large masses of highly combustible, dead material, dry branches and sclerophyllous leaves. A similar situation has also evolved in the Californian Chaparral, where the artificial prevention of natural fires is increasing the hazards and only delaying their disastrous results (Naveh 1967, Schultz 1967).

The place of goat grazing and fire in integrated upland ecosystem management

Amongst the anthropogenic defoliation agents which seem to play such an important role as homeostatic controls, goat browsing and fire are most controversial, because they have been blamed as the chief culprits for Mediterranean land ruin. However, in scientific management of natural resources, this irrational, wholesale condemnation should be replaced by a more balanced and unbiased reassessment of their place in Mediterranean hill land use in general and specifically in conservation management.

The possibilities of rational and profitable utilization of milk and meat potential of the Mediterranean black Mamber goat in rugged and shrub-covered terrain, without endangering sustained productivity, have been discussed in a special FAO seminar (French 1965). Practical suggestions to bring about a rise in the standard of goat husbandry and pasture management have been made also in Israel (Laor pers. comm., Weitz 1964), on which improved and more conservative management practices should be based.

Of great interest for the controlled use of goat browsing in Mediterranean upland reserves and parks is the recent promising experience gained in Israel by the use of improved Angora goats from Texas for mohair and meat production in fenced Maquis pastures in Western Galilee (Naveh 1962*b*, 1968). With the help of these goats, problems connected with the need for daily milking and the difficulties arising from the control of the much more agile Mamber goats could be overcome. If the good economic prospects envisaged from high-quality Angora goats in well-managed brush ranges could be realized, they could become a very attractive proposition in modern, conservative Mediterranean hill farming. At the same time, they could be used as a valuable biological tool in the conversion of dense Maquis and Garigue into open woodland and savanna pastures, in combination with cattle. Between 1952 and 1960, brush conversions for range improvement were carried out in several collective settlements in the Western Galilee by integrated ecosystem management (Naveh 1960, 1967; Soil Conservation Service 1964). In this, the suppression of undesirable dwarf-shrubs and shrubs was achieved by fire and arboricidal treatment and the encouragement of valuable pasture plants by reseeding with perennial grasses and legumes in the brush ashes together with rotational-deferred grazing. At the same time, valuable trees, such as *Ceratonia siliqua*, *Pistacia palaestina*, *Quercus* spp., were protected from fire and spraying.

On the basis of these extensive field studies it was concluded that controlled burning can be used as an efficient tool for the quick removal of dense and well-developed brush cover on high potential sites and the creation of favourable conditions for the establishment and production of perennial

grasses, such as *Oryzopsis miliacea* and *Phalaris tuberosa*, provided that the area is protected from grazing one year prior to, and after, the burning and that vigorous brush regeneration is checked.

Great objections have been expressed against the use of fire because of the danger of accelerated erosion. However, our studies revealed that in the first winter after burning dense shrubland, no trace could be detected of runoff and soil movement even on steep and rocky slopes and even after heavy early winter rain storms. Fire affects mainly the upper 5 cm of the Aoo and Ao soil profiles. These are converted into a 1–3 cm high layer of compacted ashes, charred leaf litter and humus, and provide an ideal seed-bed for broadcasted pasture plants. The organic matter content of these Maquis soils is very high, so that even after losing about a fifth by fire, 10 per cent is still retained in the total soil profile of about 30 cm and 13–16 per cent in the upper soil layer (Table 4).

Table 4. The effect of burning on organic matter of upper 4 cm of a dark brown rendzina maquis soil, beneath trees and shrubs. Mazuba—(Western Galilee). Fall 1953.

Name of plant in sampling location	Depth cm	Organic matter % Before burning	After burning
Quercus calliprinos Webb.	0–2	18·13	16·36
	2–4	16·22	13·28
Ceratonia siliqua L.	0–2	23·35	14·59
	2–4	18·27	12·05
Pistacia palaestina Boiss.	0–2	16·48	14·59
	2–4	18·27	12·32
Pistacia lentiscus L.	0–2	22·30	20·17
	2–4	16·31	14·25
Average	0–2	20·7	16·7 −4
	2–4	16·9	13·2 −3·7

This fact, together with the excellent granular structure of these Brown Rendzina and Terra rossa-Maquis soils, may explain their high infiltration capacity and stability. On poorer sites, however, with less fertile, calcareous soils, and a lower shrub cover, the danger of soil erosion is much larger, especially if these are grazed prior to and after the burn.

Together with the reseeded plants, naturally occuring, relic perennial grasses and many flowering geophytes, such as *Crocus*, *Ochrus*, *Ophyrys*,

Allium and *Colchicum* spp. spread after the fire (Loeb 1960, Naveh 1960). Our studies indicated that in addition to the opening of the shrub canopy and the release of soluble minerals (especially potassium), fire may fulfil vital functions in the removal of phytotoxic kolines and in the stimulation of germination and regeneration of these plants. If this is confirmed by our present study, fire may become an indispensible tool in conservation management.

Although good returns from such converted upland pasture ecosystems can be expected (Weitz 1964), heavy initial investments are likely to inhibit commercial application by private farmers and collective settlements. This would be less so if development schemes in mediterranean hill land were approached on a broader, regional scale and aimed at optimization of multiple use benefit for pasture, recreation, tourism, wildlife and watershed management (Naveh 1968).

Conclusions

On the basis of our present knowledge we can conclude that for the purpose of the conservation of structural, functional and biological diversity of mediterranean woodland, shrubland and grassland ecosystems, the continuation of active human intervention at one level or the other is essential.

In nature reserves a flexible and dynamic conservation policy should be adopted, similar to that proposed recently by Mörzer Bruijns for Israel (1969). In this, destructive disturbances, such as overgrazing and mass-recreation on one hand, and irreversible, non-ecological interventions, such as mono-species pine afforestations, should be avoided. Until more reliable information is gathered from systematic ecosystem and management studies, three main levels of anthropogenic intervention should be adopted:

1 Continuation of controlled 'conventional' defoliation activities—including moderate goat grazing and occasional fires—and confinement of 'modern' disturbances and activities to prescribed and restricted areas and footpaths. Buffer zones should be as large as possible.

2 Setting aside considerable portions of representative biotopes and landscape units for complete protection as control and study areas.

3 The reservation of other areas for the experimental manipulation of ecosystems, where long-term and overall effects of different intensities and modes of grazing, cutting, burning, spraying as well as planting could be tested systematically. The emphasis in these manipulation studies should be on conservation of maxium biological diversity, as outlined above, and the application of their results to larger, conventionally managed areas.

In national parks and other upland-wildlands which are open for public recreational use, our goal should be the optimization of landscape values to

enable maximum enjoyment for visitors with minimum damage to natural resources. The creation of densely planted, fire-prone and monotonous 'production forests' or inaccessible Maquis 'protection forests' will minimize these values. On the other hand, the conservation and active stimulation of biological diversity by means of integrated ecosystem management will maximize these values by the creation of edge habitats and favourable niches through the conversion of Maquis, Garigue and Batha into open forests, woodlands and savannas with well-developed and ornamental shade and forage trees and a rich herb layer.

For the remaining open upland ecosystems, the alternative to the present misuse and neglect and the forestry production or protection approach should be multiple-land use patterns based on over-all dynamic planning of scientific, ecological and technological management. This should ensure the rational utilization of these renewable resources of vegetation, wildlife, soil and water on the basis of the current and anticipated needs of society and the biological potential of these ecosystems. Some of the choices for such alternatives have been indicated above and others are described elsewhere (Naveh & Ron 1966, Naveh 1970).

These choices can be made only after a systematic and comprehensive study of the ecological, socio-economical and hydrological implications and by provision of objective parameters for cost/benefit analyses of the various alternatives and combinations in different situations. Therefore mediterranean hill-land use should give first priority to integrated upland-ecosystem studies, guided by more enlightened and unbiased approaches than those prevailing, at present, amongst most planners, decision makers and administrators of these mediterranean wildlands.

Summary

One of the chief aims of conservation of untillable mediterranean upland ecosystems which have been influenced for long periods by anthropogenic pressure, is the preservation of their striking structural, functional and biological diversity. These are threatened at present by urban, industrial and agricultural expansion on one hand and by creation of dense and monotonous Allepo pine 'production' or inaccessible Maquis 'protection' forests on the other.

Both in oak savannas and in open Maquis and Garigue, the dynamic equilibrium between phanerophytes, chamaephytes, hemicryptophytes and the geophyte and therophyte understorey, containing many flowering plants and favourable niches and edge habitats for animals, can be maintained only by active human intervention.

Therefore, a dynamic and integrated ecosystem approach is necessary in

which grazing, cutting, burning and other defoliation agents can be used as management tools. In nature reserves this implies the continuation of moderate, controlled and non-destructive intervention, together with protection and experimental manipulation of representative ecosystems. In national parks and open wildlands it implies optimization of landscape values for mass-recreation or for multiple use benefit for pasture, forest, recreation, tourism, wildlife and watershed management. This can be achieved by conversion of Maquis, Garigue and Batha into open forests, woodlands and savannas. For dynamic planning of these land-use patterns comprehensive and enlightened ecosystem research in mediterranean upland is urgently required.

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